Effects of Hydrogen Addition on RP–1 Droplet Burning in Oxygen Environment

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At present, the knowledge of processes occurring from propellant injection to combustion is limited for the tripropellant operation. Foreign researchers[1] have reported improved combustion efficiencies by adding small amounts of gaseous hydrogen to the gaseous oxygen/RP–1 reaction. Since the physical mechanism is not well understood, MSFC has initiated research in this matter under a NASA Research Announcement with the Propulsion Engineering Research Center of Pennsylvania State University. The results will be used to advance injection technology for tripropellant combustion application.

To investigate the impact of hydrogen addition to the gaseous oxygen/RP–1 combustion, an apparatus (fig. 44) was constructed to conduct experiments at Penn State. The test module is equipped with a droplet generator, flame burner, and a glass chimney for photographic observation. A flash-illumination system and camera were positioned downstream of the burner to record the RP–1 drop-size variation. Experiments were conducted on isolated individual RP–1 droplets burning in a pure oxygen environment, to which co-flowing hydrogen gas was added. From the high-magnification images of the droplets, the droplet velocity and size were determined in addition to other independent measurements. A comparison of the droplet lifetime burning in an environment with and without hydrogen addition was made (and is shown in fig. 45, together with the respective analytical predictions). The results indicate that the addition of hydrogen has no significant effect on the regression rate of the RP–1 droplet.

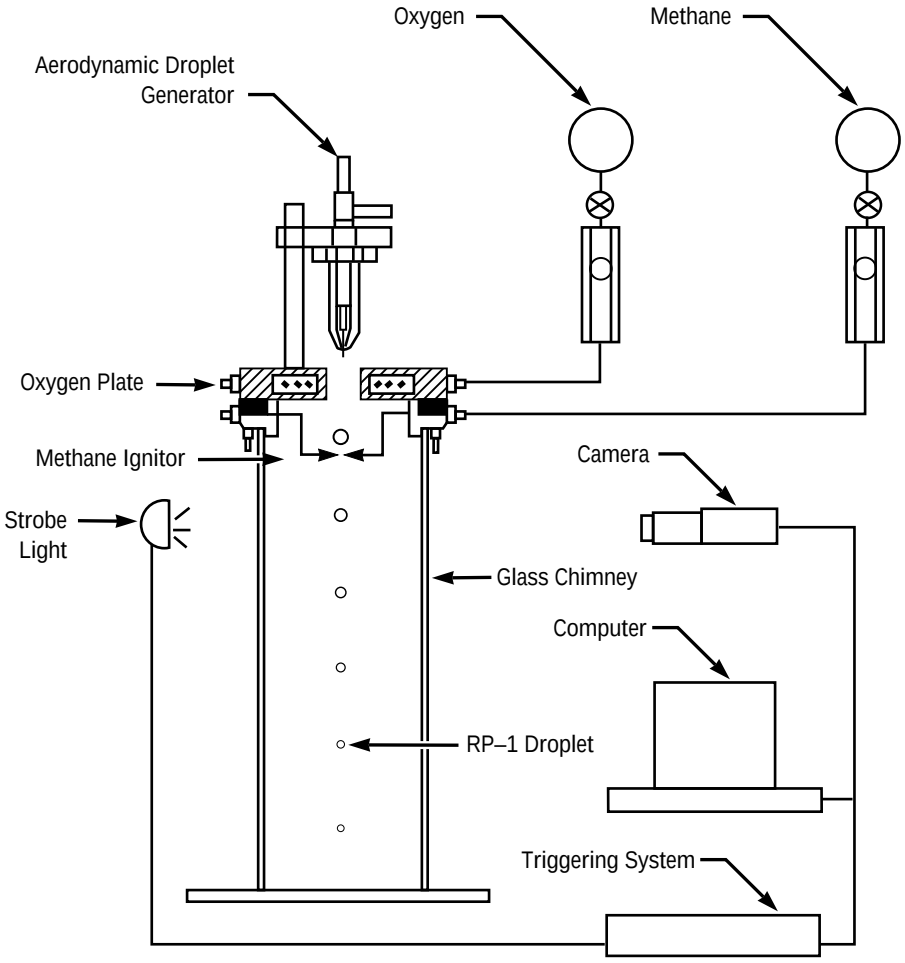

FIGURE 44.—Schematic of the experimental setup.

Reported improvements of combustion efficiency from other tripropellant combustion studies may be caused by the hydrogen affecting the RP–1 fuel-atomization process.

Penn State independently performs additional detailed measurements to verify the results and provide an experimental data base for future combustion modeling efforts.

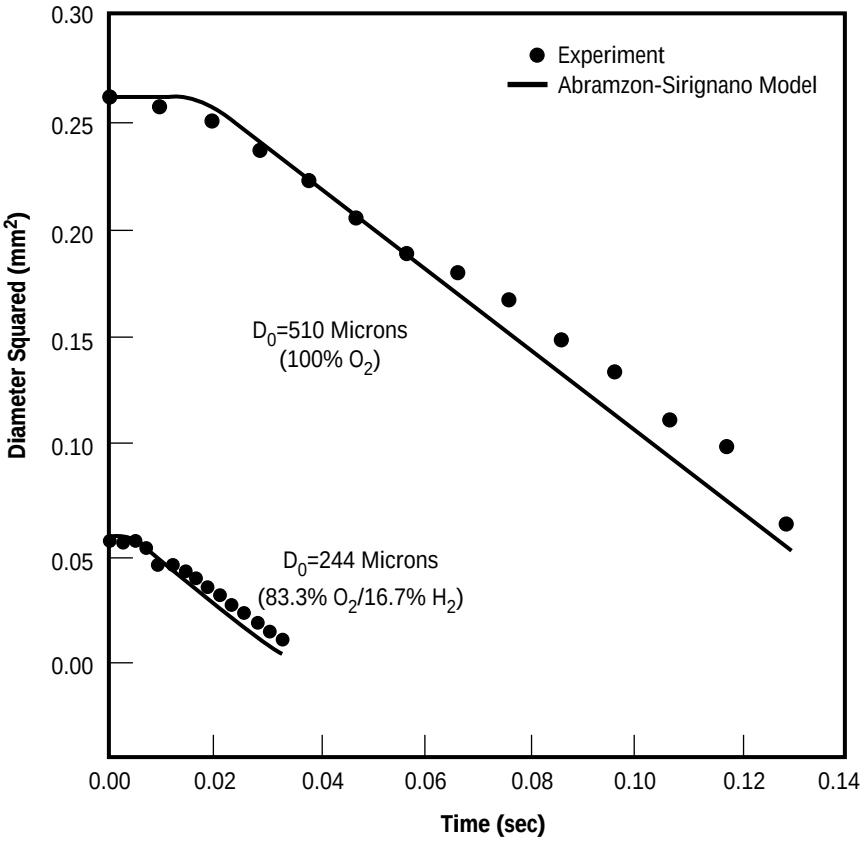

FIGURE 45.—History of RP–1 droplet size in the burning process. (Solid curves generated from Abramzon-Sirignano vaporation model at 100-percent gaseous oxygen.)

[1]Ono, Fumiei, et al. July 1992. Effects of Hydrogen Addition on Combustion Performance of a Lox/ Kerosene Rocket. Technical Report of National Aerospace Laboratory, TR–1177.

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